ERIODICAL
3(4)
3(4)

The Canadian Fish Culturist

A Department of Fisheries Publication

A Bulletin of Information and Opinion as to Fish Culture in Canada

VOLUME III

No. 4

AUGUST
1948

CONTENTS

VOLUME III No. 4

AUGUST, 1948

Page

Improved Trout Angling in a small lake after poisoning undesirable fish—M. W. Smith 3

Black Spot Disease of Bass, Part II, Snail Host of *Uvulifer Ambloplitis*—François de S. Lachance. 7

Some Records of the Food of Brown Trout in Ontario—D. H. Pike 16

Recent Increases in Growth Rate in Two Species of Lake Manitoba Fish—W. A. Kennedy 18

Summary of Literature on Aquatic Weed Control—J. Murray Speirs 20

Turbines and Descending Salmon and Trout Smolts (and Eels): IV—Book Review by A. L. Pritchard 33

Requests for earlier issues of the Canadian Fish Culturist continue to be received. A limited number of copies of the issue for December, 1947, remain on hand and distributions will be made on request until the supply runs out. However, no copies of the issues for November, 1946 and June, 1947 are now available.

Published under Authority
of
Hon. R. W. Mayhew, M.P.,
Minister of Fisheries

The Canadian Fish Culturist

A Department of Fisheries Publication

A Bulletin of Information and Opinion as to Fish Culture in Canada

VOLUME III

No. 4

AUGUST
1948

New Chief of Fish Culture Development

A contributor to the Canadian Fish Culturist and regarded an authority on British Columbia salmon, Dr. Andrew Lyle Pritchard, has recently been appointed Director of Fish Culture Development in the Department of Fisheries.

Leaving his post of Senior Biologist at the Pacific Fisheries Biological Station at Nanaimo, B.C., Dr. Pritchard comes to Fish Culture Development at a time when its activities are expanded and his duties as Director of Fish Culture Development have been enlarged in comparison to those of his predecessor, J. A. Rodd, who retired a few months ago. In addition to being responsible for administration, production and distribution of the fish hatchery stocks, and the development of cultural practice to make the fisheries more effective in commercial operation and sport fishing, Dr. Pritchard is charged with developing and administering methods of river management, fertilization of waters, control of pollution and fish predators, and control of water obstructions.

Dr. Pritchard has been with the Fisheries Research Board of Canada since 1928. An important part of his work has been his intensive research in connection with the British Columbia salmon species and he has written many scientific papers on his findings. Recently he has been in charge of the Board's Skeena River salmon investigation.

Improved Trout Angling in a Small Lake After Poisoning Undesirable Fish

by

M. W. Smith

Biologist, Atlantic Biological Station, (Fisheries Research Board of Canada)
St. Andrews, N.B.

Not infrequently in Maritime lakes, speckled trout populations, under an increasing angling pressure, decline and undesirable species become dominant. Attempts have been made to restore such lakes as suitable trout habitats by poisoning the competitors and predators of trout. Rotenone, as contained in derris or cubé powders, is an effective fish poison at low concentrations, at which its action is quite selective against fish, while most aquatic invertebrate animals remain unaffected. In the stratified waters of Potter's lake, New Brunswick, where control of undesirable fish by poisoning with derris was attempted by the writer, it was found that an almost complete kill of fish was realized, but, presumably as a result of an inadequate mixing of the poison, a few fish survived, and with reduced competition and predation the progeny of these, especially the yellow perch, soon re-populated the lake. On the other hand, Catt and Needler (1946) report a complete kill of coarse fish, principally yellow perch, by poisoning with derris the unstratified waters of MacFadden's lake, New Brunswick, and the restoration, after stocking, of an abundant trout population. To demonstrate further the utility, under favourable conditions, of poisoning undesirable fish as a method of improving trout angling, results obtained after the treatment of Bill's lake, Charlotte county, New Brunswick, with derris are herein described, together with a brief description of the lake and the fish population.

Some Characteristics of Bill's Lake

Certain morphological features of the lake are as follows:

Area.....4.2 ha. (10.5 acres)
Volume.....38,570 cu. m. (1,362,000 cu. ft.)
Maximum depth 3.0 m. (9.8 ft.)
Mean depth.....0.9 m. (3.0 ft.)

Bill's lake is a small body of water, biologically aged, and rapidly approaching senescence. Rooted aquatic vegetation has encroached over much of the lake bottom. The drainage basin covers about a square mile (2.6 sq. km.) and the outlet, after a run of a mile (1.6 km.), empties into Passamaquoddy bay. Drainage from springs is apparently sufficient to moderate the summer temperature of the deeper water, which otherwise would probably be unfavourable for speckled trout. In about a third of the area of the lake, the waters become stratified in summer although the maximum depth is only 3 metres, and some diminution of the dissolved oxygen content occurs near the bottom. Hydrographical data are given in Table I.

Table I. Hydrographical Data for Bill's Lake

Depth (metres)	Temperature (°C.)		Dissolved Oxygen (ml. per litre)		pH value	
	a*	b*	a	b	a	b
In lake						
0	25·1	15·65	5·24	5·00	6·8	6·6
0·5	23·1	–	–	–	–	–
1·0	18·25	15·45	–	4·99	–	–
1·5	16·0	15·35	5·12	–	–	–
2·0	14·65	14·3	–	4·99	–	–
2·75	12·8	13·7	3.88	–	6·2	6·6
Bog Inlet	8·7	–	–	–	5·4	–
Shore Spring I	8·8	–	–	–	6·0	–
Shore Spring II	6·45	–	–	–	5·6	–
Bottom Spring 0·8	8·65	–	–	–	–	–

*a—June 21, 1938; b—September 7, 198.

Treatment with Derris Powder

On June 16, 1938, Bill's lake was treated with 21¼ lbs. of derris powder, containing 5% rotenone, which was sufficient to give a concentration of 0.25 parts per million. To assess the effectiveness of this low concentration in killing fish under natural conditions, the lake was again treated on September 8, 1938, with the highly lethal concentration of 1 p.p.m. In the interim, the outlet was screened to prevent upward movements of fish into the lake.

Distribution was made principally by towing derris powder in a gunny sack behind a row boat. Kneading was necessary to expel the powder from the sack. By weighting and moving a sack containing derris up and down an attempt was made to insure distribution at all levels in the deeper water.

Standing Crop of Fish

The poisoning revealed the presence of the following species of fish: *Salvelinus fontinalis* (brook trout); *Couesius plumbeus* (lake chub); *Anguilla bostoniensis* (eel); *Pungitius pungitius* (nine-spined stickleback). A careful collection and enumeration of the dead fish, with the exception of the sticklebacks, was made after each treatment. The following numbers should be considered as minimal, however, since it is improbable that all the dead fish were collected.

	Trout	Chub	Eel	Stickleback
After first treatment	3	656	2,042	numerous
After second treatment	0	5	204	few

As applied under the conditions obtaining in Bill's lake, 0.25 p.p.m. was not a sufficiently high concentration of derris to give a complete kill of fish.

Samples of eels (721) and chub (508) were preserved and subsequently measured and weighed. Assuming these samples to be representative, standing crops of 0.8 lb. of chub and 70.8 lbs. of eels per acre were calculated. The total standing crop of fish was considerably higher than the average of 22 lbs.

per acre (17 to 35 lbs.) recorded for five other lakes lying in regions of New Brunswick and Nova Scotia with similar rock formations and soils (Smith, 1938, 1940, 1941). The higher level of productivity in Bill's lake may well reflect its more advanced biological age.

Trout Angling

As learned from local sportsmen, Bill's lake provided moderately good trout angling in the past. The catch declined, however, in the late twenties to the point where improvement was attempted by stocking (1928, 1930, 1931 and 1932 with 10,000, 5,000, 10,000 and 5,000 No. 1 fingerlings respectively, and with 100 and 262 old trout in 1930 and 1931—Rodd (1928, 1930, 1931, 1932)). No lasting improvement resulted, for during the years immediately prior to 1938 little angling was done in Bill's lake because, as locally stated, few, if any, trout could be caught. It was largely on this information that Bill's lake was selected for toxicity tests, since it was not desired to destroy an appreciable population of trout. The poisoning in 1938 revealed only three trout, but at least 2,246 eels which may be considered both competitors and predators of the former species.

Following the poisoning the lake was not stocked with trout, nor is it known to have been fished until 1942. In May of that year two anglers caught six trout 6 to 7 inches long. Apparently the lake was becoming restocked, during a period of little angling and before the re-establishment of a dominant eel population, from a reservoir of small trout which populate the outlet. (It would appear that the small outflow of water from the lake when poisoned did not result in a toxicity sufficient to destroy the fish in the outlet stream). On April 26, 1944, an angler took 17 trout in one and one-half hours of fishing. These trout averaged 11.0 inches (27.9 cm.) in total length and 0.4 lb. (181 gm.). As a result angling increased, and there are definite records of 132 trout being caught in 1944, or a yield of 5.3 lb. of trout per acre (5.9 kgm. per hectare) if the above catch may be considered representative. For comparison, the annual yield of trout to anglers from eight larger neighbouring lakes, biologically less aged than Bill's, has been in average 0.7 lb. of trout per acre (Smith, 1946). There are records of 42, 35 and 12 trout being taken in 1945, 1946 and 1947 respectively. No formal creel census was maintained on the lake, and a complete record of the number of trout angled was not secured. From the evidence at hand, however, it is indicated that the trout population is declining. Eels are now present in the lake (entering as elvers from the sea), and it would not be surprising if the conditions that existed in 1938 will soon obtain again in Bill's lake, since here the eels apparently find a very favourable environment.

Comment

It is concluded that the destruction of eels in Bill's lake by poisoning with derris powder resulted in the re-population of the lake with trout from a stock in the outlet stream. Since it is difficult to prevent the migration of young eels into a lake, repeated treatment with poison would probably be

necessary for continued control of this species. However, the results argue for the effectiveness of the poisoning procedure as a means of destroying fish inimical to trout, and point to more permanent control when dealing with species whose re-entry into a lake is more easily prevented than in the case of the eel (cf. Catt and Needler, 1946).

Difficulty has been experienced in successfully treating lakes with stratified waters. Nevertheless, poisoning unwanted fish has sufficient merit as a fish-cultural procedure to warrant additional investigation into techniques of obtaining a proper distribution of poison in such waters. In any case, it is to be appreciated that the resultant improvement in trout angling is dependent upon the productive capacity of the lake.

REFERENCES

CATT, JAMES and A. W. H. NEEDLER. *Restoration of an abundant trout population by poisoning introduced yellow perch and restocking.* Can. Fish Culturist, *1* : 9-12, 1946.

RODD, J. A. *Annual Report on Fish Culture for 1928, 1930, 1931 and 1932.* Department of Fisheries, Ottawa. 1929, 1932 and 1934.

SMITH, M. W. *A preliminary account of the fish populations in certain Nova Scotian lakes.* Trans. Amer. Fish. Soc. *67* (1937) : 178-183, 1938.

Fish production in Trefry's lake, Nova Scotia. Fish. Res. Bd. Can., Prog. Rep. Atl., No. 26, pp. 6-8, 1940.

Treatment of Potter's lake, New Brunswick, with rotenone. Trans. Amer. Fish. Soc. *70* (1940) : 347-355, 1941.

The yield of native and planted trout to anglers from Charlotte county lakes, New Brunswick. Fish. Res. Bd. Can., Prog. Rep. Atl., No. 36, pp. 6-10, 1946.

Black Spot Disease of Bass

PART II. SNAIL HOST OF UVULIFER AMBLOPLITIS[1]

by

François de S. Lachance

Junior Research Assistant (now Medical Entomologist Colonial Service, Nigeria)

As was shown in the first paper of this series (10), black spot disease in bass is widely distributed throughout the lakes of the Province of Quebec, and has been recorded from 32 of the 65 lakes and streams investigated. "Black spot" in bass in Quebec is caused by the metacercarial or infective stage of *Uvulifer ambloplitis*, a trematode which lives as adult in the belted kingfisher. The bird becomes infected by feeding on the black spotted fish. The adult parasite lays minute eggs, which pass into water in the bird's excreta and there, after a complicated development in certain species of snails, give rise to motile organisms called Cercariae which attack the fish, become encysted in them, and give rise to black spots. Therse cercariae were originally described elsewhere as *Cercaria bessiae.*

During the fall and winter of 1945-46 an endeavour was made to discover what species of snails found in the Quebec lakes and streams could act as intermediate hosts for this parasite, as well as to study the development of the metacercaria.

Technique

Weed-inhabiting snails were collected from as many lakes and streams in the Eastern Townships and Laurentian Mountain areas as feasible, by sweeping a net through the aquatic vegetation. This net consisted of an open box, about six inches deep, cut from ordinary fly-screen netting, inserted into a rectangular frame, eight inches wide by 18 inches long, with a five-foot rod as a handle. However, ramshorn snails of the genus *Helisoma* (Fig. 1), being fairly large and not in the habit of congregating in one spot in numbers had to be collected by hand.

In the laboratory the snails were placed, two or three at a time, in a half-pint milk bottle and examined by a hand lens twice daily, in the morning and at night. Whenever cercariae were present, they could be seen suspended in the water, head downward with the furcae of the tail spread widely (Fig. 4). After tentative identification of cercariae in the water had been made by this method, a check was made by microscopical examination. All morphological observations were made on living material, both stained and unstained. Several intra-vitam stains were tried. The best of these were those used by Talbot (13) for the study of schistosome cercariae. The cercariae were first stained with very dilute neutral-red for about five minutes, then two or three

[1]*Contribution from the Institute of Parasitology, Macdonald College, McGill University, with financial assistance from the National Research Council. Part I was published in The Canadian Fish Culturist—June 1947.*

drops of nile blue were added. Due to the rapid penetration of the nile blue they were ready for study within a few minutes. In some instances, they were stained in neutral red followed by orange G. This stain was found more useful in staining the excretory system. Aqueous mounts of intravitally stained cercariae can be preserved for a considerable length of time if the cover glass is surrounded by a film of melted vaseline or glycerine jelly to prevent evaporation of the water..

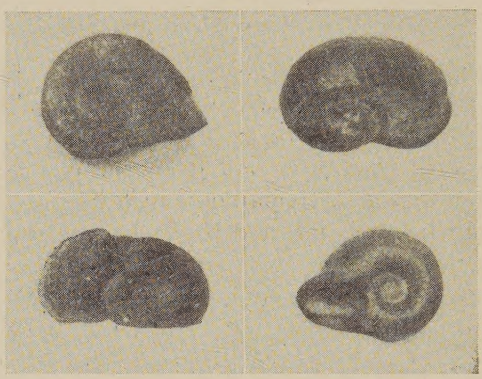


FIG. 1—*Helisoma anceps*, the natural intermediate host of *Uvulifer ambloplitis* in Quebec.

Measurements of cercariae were made with dead specimens, due to the fact that live cercariae have too great a power of extension and contraction. The best method of killing the cercariae was to place the water containing the cercariae in a small glass bowl, and to add an equal amount of boiling ten per cent formalin, pouring the latter in quickly. By this means very few specimens were distorted.

Two methods were used for obtaining matacercariae free from their cysts in infected fish. The first method consisted of placing the flesh of the infected specimen in artificial digestion fluid containing 5 grams Pepsin and 7 cc. of HCL per litre of normal saline. Usually a few hours at 40°C. were found to be sufficient to free the metacercariae which were found at the bottom of the container. The second method was a mechanical one, the cyst being removed from the fish tissue with a pair of fine forceps and placed on a microscope slide with a drop or two of water. A cover slip was then placed lightly over the living larval trematode and the temporary mount was ready for study. Studies were made on both stained and unstained, living and dead specimens.

Intra-vitam stains, as used in the study of the cercariae, were not found to be more useful or efficient than unstained live material. Permanent stains, e.g. Gower's alum-carmine, however, were found to be useful.

All drawings of cercariae and metacercariae were made with the aid of a camera lucida, but the detail drawing of the cercariae (Fig. 3) is a diagrammatic representation of the interpretations of the different structures from the studies of the large series of specimens used.

Snails Collected and Examined

The following species of snails (15) were examined for cercarial infection:—

Helisoma trivolvis macrostomum (Whiteaves)
H. campanulatum (Say)
H. anceps latchfordi (Pilsbry)
Amnicola limosa
Lymnaea stagnalis
Bythinia tentaculata
Physa sp.

The snails were collected in from a few inches to about three foot of water. The majority were located on muddy bottom and were usually covered with dead organic material. Very few lived on rocks, aquatic plants and rotten logs; this is particularly true of the genus *Helisoma*.

The snails were identified by Mr. A. LaRocque of the Geological Survey, Ottawa. In this survey, *H. anceps latchfordi* was found in Wilson's lake (lac LaPeche) in the Gatineau district, and Mr. LaRocque notes that this is a new locality for this species.

Five species of snails were found to be infected with cercariae as follows:—

(a) *H. trivolvis macrostomum* infected with a furcocercous cercaria identified as *Cercaria wardi* (11).
(b) *H. anceps* infected with *Xiphidiocercaria* sp.
(c) Several snails belonging to the genus *Physa* sp., infected with a furcocercous cercaria identified as *Cercaria douglasi* (1).
(d) *Limnaea stagnalis* infected with an unidentified furcocercous cercaria.
(e) *Bythinia tentaculata* infected with an unidentified cercaria.

Helisoma anceps was the only snail found infected with the black spot cercaria (=*C. bessiae*). The percentage of cercariae in the snails collected was only 0.4 per cent. This species of snail has not been recorded previously as a host for this parasite.

In spite of the fact that *Helisoma anceps* was the only snail found infected in nature with the cercaria of *U. ambloplitis* in the province, and that *H. trivolvis* and *H. campanulatum*, the naturally infected hosts in the United States were found free from infection, there is still a possibility that the latter two may carry the disease in nature here. Several thousand *Helisoma* snails were examined during the present survey, but many thousands more need to be collected from a wide area over a long period of time and examined for the presence of escaping cercariae. This area should include both the Eastern Townships and the Laurentians.

Morphology and Behaviour of the Cercaria

This is a holostome cercaria without a ventral sucker and with unpigmented eye spots; body about the same width as tail stem and bent ventrally when hanging at rest in the water (Fig. 4); digestive system very rudimentary; penetration glands six in number; tail-stem without caudal bodies; body spines on first third of the body; genital primordium large in size (Fig. 3).

The cercariae can be seen suspended in the water, head downward. In this position, the furcae or tail branches are held at a slightly obtuse angle to the tail-stem, the tail-stem itself very much like a closed finger (Fig. 4).

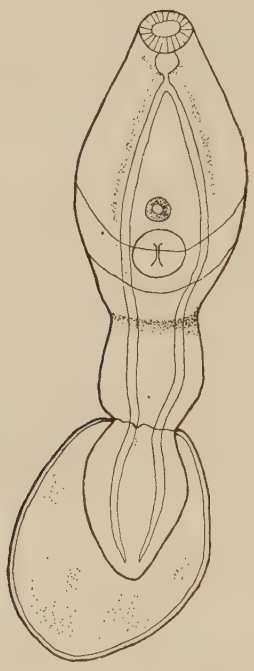


FIG. 2—Metacercaria of *Uvulifer ambloplitis* escaping from its cyst.

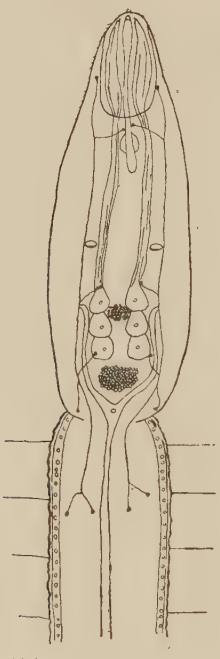


FIG. 3—Cercaria of *Uvulifer ambloplitis* showing internal anatomy of body and part of tail-stem.

After the free suspended cercariae have remained motionless for a while, they become suddenly active and move quickly upward for a short distance, until they regain their original position. They always move backward with the spiral wriggling movement characteristic of the holostome cercariae.

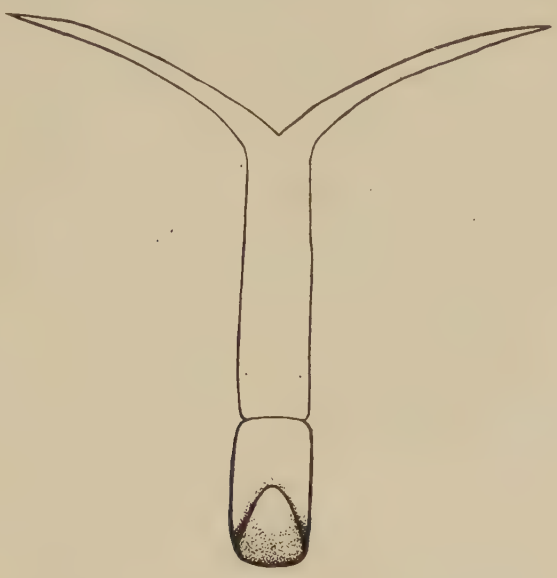


FIG. 4—Cercaria of *Uvulifer ambloplitis* hanging at rest in water. Note that the fore-body is bent ventrally upon itself.

Infection Experiments and Results

Five species of fish were exposed to infection with the cercaria of *U. ambloplitis*.

(1) *Ambloplitis rupestris*—rock bass.
(2) *Lepomis gibbosus*—common sunfish.
(3) *Simotilus atromaculatus*—horned dace.
(4) *Catostomus catostomus*—white sucker.
(5) *Lebistes reticulatus*—guppy.

The cercariae used in these experiments were obtained from snails collected in stream No. 2, one-and-three-quarter miles east of Foster, Quebec.

Because the rock bass and sunfish were collected in the Ottawa River, they were kept in the laboratory for three weeks before being exposed to infection to ensure that they did not carry a natural infection and to acclimatize them to laboratory conditions. The white suckers, horned dace and guppies had been in the laboratory for two years. Five rock bass, two sunfish, and a large number of white suckers, horned dace and guppies were used as controls.

The methods and times of exposure in carrying out the experimental infections with the species of fish mentioned above, were quite varied, so that each experiment requires individual description. Newly emerged cercariae

were used in all the experiments; the water was kept at a temperature varying between 18 and 22°C., except for two days when the temperature dropped to 16°C. The pH of the water in which the snails were kept was at all times exactly the same as the water in which the experimental fish were kept.

Three rock bass were placed in water with varying numbers of cercariae. The first one was exposed to about 300 cercariae for eight hours, the second to several hundred cercariae for 11 hours, and the third for 24 hours. This procedure was repeated three times at one-day intervals.

A sunfish was exposed to infection in the same manner as the third rock bass.

In these experiments the fish became very excited and showed great nervousness. They moved by quick and sudden jumps and spurts, rubbing their body on the sides and bottom of the aquarium. However, after about an hour they became quiet, remaining in one corner of the tank near the surface of the water, but each time the writer approached the tank during the infection period the fish began their characteristic movements.

Another rock bass was exposed by placing it and the cercariae in 60 cc. of water. Using the binocular dissecting microscope, with a 16x magnification, the penetration of the cercariae was observed. This fish was exposed to infection for 60 minutes, then removed to its original aquarium. This procedure was repeated four times in two days.

The cercariae were seen penetrating under the scales of the fish, but it was very difficult to observe which part of the fish they penetrated most frequently. This difficulty could hardly be overcome, due to the fact that the fish was in almost constant motion. However, the cercariae were seen to throw off their tails within two minutes of coming in contact with the fish. The actual time they took to penetrate the fish and disappear from view, after throwing off their tails, could not be ascertained, partly due to the fact that the cercariae do not attack the fish simultaneously.

Four sunfish were exposed to infection on different occasions in the same manner as the rock bass mentioned above. The penetration of the cercariae could not be observed because there was too much debris introduced in the small aquarium with the cercariae. After 40 minutes the fish were removed and the water containing the cercariae in which the fish had been exposed was examined under the low power of a compound dissecting microscope. A few tail-less cercariae were present, crawling on the bottom of the small aquarium; many tails, however, were seen floating about in the water. Among the tail-less cercariae on the bottom were several which were degenerating quickly. It is interesting to note that not one complete cercaria was noticed.

On the 18th and 19th days after the initial penetration of the cercariae in all the experiments mentioned above, some very small whitish spots could be seen on the rock bass and the sunfish, particularly at the base of the caudal fin, which was later found to be the most heavily infected part of the fish. On the following days, these whitish areas were seen more easily, being larger and numerous. On the 22nd and 23rd days, very dimly pigmented black spots were observed in these areas; these black spots increased in size and

number from day to day, and by the 28th and 29th days, they were quite large and obvious. These results confirm the findings of Krull (9) and Hunter and Hunter (5, 6), who reported that the fully developed cysts appear in about three weeks if the organisms are kept at a temperature of between 18 and 21°C. Black pigment-bearing cells appear in the loose connective tissue of the outer coat sometime during the third week.

The location of the cyst in the experimentally infected fish varied considerably. In one of the small rock bass, the cysts were found mostly at the base of the caudal and dorsal fins, while in another larger rock bass, the cysts were concentrated mostly at the base of the caudal fin, around the eyes, and in the mouth cavity. In most cases, cysts were recovered, also, from the myotomes, integument, and between the fin rays. Hughes (3) and Krull (9) have both reported finding cysts under the surface of the head in addition to the above mentioned areas, while Hughes (3) has, also, recovered them from the peritoneum.

The final experiments employed white suckers, horned dace and guppies. These three species of fish were kept in separate tanks of two gallons each throughout the experiments. They were exposed to infection by introducing hundreds of cercariae into the aquarium each time. These experiments proved that these three species of fish could not be infected with the cercariae of *Uvulifer ambloplitis*.

Morphology of Cyst and Metacercaria

The cyst is composed of two parts, an outer black pigmented covering of host origin and an inner non-cellular hyaline layer of parasite origin. The inner cyst is thin, very tough, and closely invests the parasite. Within the cyst the metacercaria is folded back upon itself. When the animal is freed from its cyst, it is seen to have a deep constriction dividing the body into two well defined regions, the fore and hind-bodies (Fig. 2).

Effects of Parasites on Fish

Krull (9) carried out penetration experiments with *Cercaria bessiae* on the common sunfish (*Eupomotis gibbosus*). He observed that heavy infection caused death of fish fry in two to four days, but showed that enormous infestations could be built up in small and medium size fish, and that fish of all sizes responded to the penetration of the cercariae immediately and in a very characteristic way. They were stimulated to activity and went through the water by spurts in all directions. Soon after the initial attack, they attempted to detach the cercariae by rubbing their bodies against the bottom and sides of the aquarium or against objects therein. This activity subsided in about 15 minutes, being followed by a flexing of the body while suspended in the water; this lasted for several seconds. Finally, the fish became exhausted and came to rest in some particular spot near the surface of the water, remaining motionless for an hour or more before resuming normal activity.

In 1933, Cross (2) made a study of perch and small mouth black bass and their parasites (cestodes, Acanthocephala, and trematode cysts). He showed that there was a decided difference in average length and weight

when uninfected and heavily infected fish are placed in separate groups according to the age of each specimen. Incidentally, perch and bass in one soft water lake were entirely free from trematode cysts in 1931 and 1932, but in 1933, after two summers of fertilization of the same lake with calcium and phosphorus, six per cent of the fish examined were infected with strigeid cysts. This seemed to be paralleled by an increase in the snail population.

Hunter and Hunter (5, 6, 7) in 1934 and 1938 reported that a heavy infection with metacercariae of *U. ambloplitis* in young and small mouth black bass caused a statistically significant loss in weight when compared with control fish. They suggested that this loss was due in part, at least, to disturbance of the normal metabolism of the host.

In 1941, Hunter and Hamilton (4) gave a report of their studies on host reactions to the metacercariae of *U. ambloplitis;* their findings are summarized as follows:—

(a) An inner hyaline cyst of parasite origin appears within two to four days of the time the parasite reaches its definitive location.

(b) The cysts appear to develop near the internal or external perimysium of the muscles.

Summary

Black spot in bass in Quebec is caused by the metacercarial stage of *Uvulifer ambloplitis*, a trematode parasite of the belted kingfisher.

Not only were small mouth black bass and rock bass found to be infected, but sunfish were, for the first time, shown to suffer in nature from the same disease.

The snail intermediary in Quebec was shown experimentally to be *Helisoma anceps*.

H. trivolvis and *H. campanulatum*, which had been found to be infected in New York and elsewhere were not found infected here.

The cercaria encysts at the base and between the rays of the fins (especially the pectoral and caudal), around the eyes, in the mouth cavity, in the skin, and in the myotomes.

The encysted metacercaria stimulates the production of a black pigment in the third week after infection and causes the characteristic black spot.

Helisoma anceps is recorded for the first time from Wilson's Lake, where the disease is quite prevalent in bass.

Nine species of snails were found and examined during the survey. *H. anceps* is a newly recorded host for *Cercaria bessiae* in Canada.

REFERENCES

(1) Cort, W. W. and Brooks, S. T. *Studies on the holostome cercariae from Douglas Lake*, Mich., Trans. Am. Micro. Soc., 47 : 179-221. 1928.

(2) Cross, S. X. *Some host parasite relationships of fish parasites of the trout lake region of northern Wisconsin.* (University of Wisconsin). Abstract in J. Parasit. 20 : 132-133. 1933.

(3) Hughes, R. C. *Studies on the trematode family Strigeidae (Holostomidae).* No. VI. *A new metacercaria Neascus ambloplitis* sp. nov., *representing a new larval group.* Trans. Amer. Micro. Soc. 46 : 248-267. 1927.

(4) HUNTER, G. W. III. and HAMILTON, J. M. *Studies on host-parasite reaction to larval parasites.* IV. *The cyst of Uvulifer ambloplitis* (Hughes). Trans. Amer. Micro. Soc. 40 : 498-507. 1941.

(5) HUNTER, G. W. III. and HUNTER, W. S. *The life history of the black grub of bass. Crassiphiala ambloplitis* (Hughes). J. Parasit. 20 : 328. 1934.

(6) HUNTER, G. W. III. and HUNTER, W. S. *Further studies on fish and bird parasites.* Supplt. 24th Ann. Rept. New York State Conservation Dept., Rept. Biol. Survey, No. 9, Mohawk-Hudson Watershed. 1934.

(7) HUNTER, G. W. III. and HUNTER, W. S. *Studies on host reactions to larval parasites.* I. *The effect on weight.* J. Parasit. 24 : 477-481. 1938.

(8) KRULL, W. H. *Studies on the development of Cercaria bessiae Cort and Brooks*, 1928. J. Parasit. 19 : 165. 1932.

(9) KRULL, W. H. *Cercaria bessiae Cort and Brooks*, 1928, *and injurious parasite of fish.* Copeia. 69 : 73. 1934.

(10) LACHANCE, F. DE S. *Black spot disease of bass.* Part 1. *Distribution of the disease.* Candn. Fish Culturist. 1 : 16-21. 1947.

(11) MILLER, H. M. Jr. *Notes on some furcocercous larval trematodes.* J. Parasit. 10 : 35-46. 1923.

(12) PRICE, E. W. *Distomulum oregonensis Ward and Mueller.* J. Parasit. 15 : 290. 1926.

(13) TALBOT, B. S. *Studies on schistosome dermatitis.* II. *Morphological and life history studies of schistosome cercariae, C. elvae* Miller, 1923, *C. stagnicolae* n.sp., *and C. physellae* n. sp. Amer. J. Hyg. 23 : 372-384. 1936.

(14) WARD, B. W. and MUELLER, J. F. *A new pop-eye disease of trout-fry.* Archiv f. Schiffs-und Tropenhygiene : 30 : 602-609, 1926.

(15) WARD, H. B. and WHIPPLE, G. C. *Fresh-water biology.* John Wiley & Sons, Inc., New York.

Some Records of the Food of Brown Trout in Ontario

by

D. H. Pike

(Student, Dept. of Zoology, University of Toronto)

Examination of the contents of the stomachs of thirty-two brown trout caught in southern Ontario showed that twenty-six had eaten insects, ten had eaten crayfish and six had taken fish.

The stomachs examined in this study were taken from trout caught by Mr. Walter F. Wilson, of Kitchener, in the Speed, Sydenham and Saugeen rivers, Whiteman's Creek and River Styx in the counties of Wellington, Grey and Brant.

In the examination of the stomach contents, the number and volume of organisms taken from the surface and from below the surface were recorded separately. Detailed analysis of the stomach contents of each trout is given below.

The findings may be summarized as follows:

The trout ranged in size from $9\frac{1}{2}$ to 20 inches.

Both insects and crayfish had been eaten by trout of all sizes from $9\frac{1}{2}$ to 20 inches. Fish were eaten only by the larger trout, that is those from $13\frac{1}{2}$ to 20 inches in length.

Of the insects eaten 79% by volume had probably been taken from below the surface of the water and 21% from the surface. By number the corresponding percentages were 29 and 71.

The largest numbers of surface insects and terrestrial insects were found in the stomachs of the smaller trout ($9\frac{1}{2}$-12 inches). Small Gerridae *(Hemiptera)* made up about 50% of these by number. In this connection it is possibly significant that the only trout caught on grasshopper bait were two small ones 10 and 12 inches in length respectively.

The only fish found in the stomachs were cottids.

Table 1. Number, Volume and Kinds of Organisms Found in Brown Trout Stomachs. Numbers in parentheses indicate volume in cc's.

Field No.	Length inches	Date and Time taken 1944	Locality	No. of aquatic organisms in stomach				No. of terrestrial insects in stomach	Total Vol.
				Fish	Insects	Crustacians	Total Vol.		
1	20″	12:45 pm July 22	Speed River	0	0	1 crayfish	1.0	0	0
2	20″	5:30 pm May 7	Speed River	2 cottid (2.5)	2 (2.0)	0	4.5	0*	5.0
3	18½″	8:00 pm May 24	Sydenham River	0	13	0	11.0	0	0
4	18¼″	11:30 am May 14	Speed River	1 cottid	0	0	2.0	0	0
5	18″	6:30 pm June 6	Unnamed River	1 cottid (1)	0	0	4.0	0	0
6	17″	1:30 pm July 22	Speed River	0	0	1 crayfish	0.1	0	0
7	17″	9:30 pm June 4	Speed River	0	0	0	0	6	1.5
8	16½″	Aug. 20	Speed River	0	0	1 crayfish	2.0	1	1.1
9	16″	10:00 am Aug. 12	Speed River	0	0	1 crayfish	5.8	4	0.5
10	15½″	8:50 pm May 21	Speed River	2 cottid	0	0	5.4	0	0
11	15½″	6:00 pm May 18	Sydenham River	Miscellaneous			2.8	0	0
12	15½″	6:00 pm May 18	Sydenham River	0	6	0	2.0	0	0
13	14″	6:00 pm Aug. 12	Speed River	0	34	0	6.5	0	0
14	14″	6:30 pm June 18	Whiteman's Creek	0	1	0	0.1	1	
15	14″	5:00 pm July 22	Speed River	0	0	1 crayfish	2.0	0	0
16	13½″	6:30 pm June 2	Saugeen River	0	0	0	0	7	6.0
17	13½″	5:30 pm May 3	Speed River	2 cottid (5)	5 (1.5)	0	6.5	2	1.5
18	13″	12:30 pm June 10	Speed River	0	3	0	1.2	0	0
19	13″	5:00 pm June 18	Whiteman's Creek	0	0	1 crayfish	5.0	0	0
20	13″	Aug. 20	Speed River	0	1	0	0.1	1	
21	12½″	6:00 pm May 31	Whiteman's Creek	0	23	0	15.0	0	0
22	12″	4:00 pm May 17	River Styx	0	2	0	0.1	0	0
23	12″	6:00 pm Sept. 3	Speed River	0	2	0		0	0
24	12″	5:30 pm Sept. 3	Speed River	0	12	0	3.0	89	2.5
25	11½″	5:30 pm Aug. 12	Speed River	0	3	1 crayfish	1.8	1	0.2
26	11″	Aug. 20	Speed River	0	1 (0.1)	1 crayfish	0.3	7	0.8
27	10½″	7:35 pm July 29	Speed River	0	1	0	0.0	50	1.0
28	10½″	7:30 pm July 29	Speed River	0	0	0	0.0	0	0
29	10″	5:15 pm July 22	Speed River	0	0	0	0.0	0	0
30	10″	6:30 pm July 22	Speed River	0	0	0	0.0	14	0.2
31	10″	6:30 pm June 10	Speed River	0	3	0	0.4	0	0
32	10″	6:30 pm June 10	Speed River	0	17	0	1.5	8	0.5
33	9½″	Aug. 20		0	0	1 crayfish	0.1	107	1.6
34	9½″	11:00 am April 30	Lower Speed River	0	2 (1.0)	1 crayfish	1.6	1	0

*Contained 1 frog.

Recent Increases in Growth Rate in Two Species of Lake Manitoba Fish

by

W. A. Kennedy

(Associate Biologist, Central Fisheries Research Station, Winnipeg)

In the winters of 1945-46 and 1946-47 the Fisheries Research Board of Canada conducted a survey of the Lake Manitoba fishery with the active co-operation of the Manitoba Department of Mines and Natural Resources. One of the things discovered during the survey was that there had been an increase in average growth rate of saugers, *Stizostedion canadense*, and of dore, *Stizostedion vitreum*, during recent years. Some scales collected by the late D. Hinks in 1937-38, when he was employed by the Manitoba Government, were indispensable in establishing this fact.

Unfortunately part of Hinks' records have been lost, including records of the lengths and weights of the fish whose scales were taken in 1937-38. However, the size of mesh in which each was taken is known and this gives a rough index of the size of the fish. Standard methods were used to determine the ages of the fish from which these scales had been taken, and of the fish taken in our survey.

Table 1 shows that each size of gill net mesh took more older saugers in the winter of 1937-38 than in the winter of 1945-46. Since gill nets tend to select fish of a specific size range, this indicates that saugers of any given size were older in 1937-38 than in 1945-46. They were approximately as big after five years growth in 1945-46 as they were after seven years growth in 1937-38.

Similarly, Table 2 shows that any given size of gill net mesh took more older dore in the winter of 1937-38 than in the winter of 1945-46. They were approximately as big after four years growth in 1945-46 as they were after five years growth in 1937-38.

There can be little doubt that the growth rates of both saugers and dore increased between the years just prior to 1938 and the years just prior to 1946. Also the growth rate of saugers increased by more than did that of dore. An explanation can be found in the history of the fishery since 1930.

Prior to 1930 saugers were virtually unknown to the commercial fishermen of Lake Manitoba. During the thirties they began to appear in the catch in ever increasing numbers. There was a prolonged drought at the time and as a result the water level of Lake Manitoba gradually subsided, and there is good reason to believe that ecological conditions changed enough, as a result, that saugers were able to increase greatly in numbers. At the same time, probably because of the economic depression then prevalent, considerable numbers of gill nets whose mesh size was less than the then legal $3\frac{3}{4}$–inch minimum were being used. These nets of illegal mesh were able to catch saugers while the legal nets could not, so that more and more illegal nets were used. Eventually, in the winter of 1940-41, nets of $3\frac{1}{4}$-inch mesh or greater

were legalized. In that year and the next great catches of saugers were made and this species, which had been almost unknown such a short time before, became the most important one. It has remained the most important, or nearly the most important, ever since, although the catches have been considerably less than in the peak years, probably partly because of the end of the drought.

Almost four times as many fish were caught in the winters of 1940-41 and 1941-42 as in the average winter since then. Also in the four winters prior to 1940-41 production of saugers was higher than after 1941-42 even though it must have been almost entirely from an illegal fishery—hence from curtailed fishery. It is therefore reasonable to assume that there were more saugers present in the years just prior to 1937-38 than in the years just prior to 1945-46. The increase in growth rate of saugers can, then, be attributed to a decrease in numbers by exploitation.

The increase in growth rate of dore can also be attributed to a decrease in numbers of saugers, since saugers and dore are probably competitors for food at all stages in their life history. The fact that the growth rate of dore changed by less than did the growth rate of saugers indicates that inter-specific competition is less severe than intra-specific competition.

Table 1.

A comparison of the age distributions (percentage in each age group) in samples of saugers taken from Lake Manitoba in 1937-38 and in 1945-46 by 3-inch, 3¼-inch and 3½-inch mesh gill nets (stretched measure). Some data from 3¾-inch mesh are not included because only two saugers were taken by it in 1945-46. The Roman numeral refers to the year of life, for example an age IV fish is in its fourth year, which, since all were taken during the winter is approximately the same as being exactly 4 years old.

Mesh Size	Season	Number in Sample	IV	V	VI	VII	VIII	IX	X	XI	XII
3-inch.....	1937–38	59	–	5	25	24	22	19	5	–	–
	1945–46	84	4	58	29	8	1	–	–	–	–
3¼-inch.....	1937–38	471	1	7	17	30	24	15	5	–	1
	1945–46	420	2	69	22	5	1	1	–	–	–
3½-inch.....	1937–38	30	–	–	13	34	20	17	10	3	3
	1945–46	167	8	44	38	7	2	1	–	–	–

Table 2

A comparison of the age distributions (percentage in each age group) in samples of dore taken from Lake Manitoba in 1937-38 and in 1945-46 by 3-inch and 3¼-inch mesh gill nets (stretched measure). Some data from 3½-inch and 3¾-inch mesh are not included because only four dore were taken in each in 1937-38.

Mesh Size	Season	Number of Sample	III	IV	V	VI	VII	VIII	IX	X	XI
3-inch.....	1937–38	48	6	27	38	27	2	–	–	–	–
	1945–46	71	18	55	17	9	1	–	–	–	–
3¼-inch.....	1937–38	215	–	13	33	37	10	4	4	3	–
	1945–46	73	4	23	38	18	14	0	0	2	1

Summary of Literature on Aquatic Weed Control

by

J. Murray Speirs

(of the Ontario Fisheries Research Laboratory, Department of Zoology, University of Toronto)

Three main methods of attack have been tried for the control of undesired aquatic plants; (1) chemicals may be added to the water or sprayed on emergent parts of the plants, (2) biological controls, either plants or animals, may be added to the water, and (3) mechanical methods may be used. In presenting the available information on each method of control, the following topics will be considered: (1) the field of usefulness of the particular method, (2) method of application, concentration and quantities of chemicals to be used, and when possible their approximate cost, (3) the effects of the treatments not only on the plants but on other forms of life in the water and on the potability of the water, and (4) a bibliography of the literature dealing with each method.

Mode of Action of Various Herbicides

Green plants take carbon dioxide and water, and using light energy which they absorb by chlorophyll in the chloroplasts of the leaves, they manufacture these raw materials into sugars. These sugars then combine with oxygen, providing the source of energy for the essential life processes of the plant—respiration, growth and storage of food reserves as starch. These life processes are carried out in a protein medium called protoplasm. This must remain in a liquid (or sol) form so that the raw materials can be transported to regions of chemical change, the metabolized products can be used for growth or storage and waste products can be eliminated.

The various herbicides owe their lethal actions to different modes of interference with the normal chain of events outlined above. Copper sulphate and other copper salts are protein precipitants, which kill by stopping the transport of materials. Arsenicals such as sodium arsenite inhibit respiration by blocking specific enzymes in the respiratory system (Breusch, 1944). Chlorine (as from sodium chlorate or chloramine in solution) forms hypochlorous acid, an active oxidizing agent, which apparently kills the plants by burning up their energy resources: bleaching is the visible effect of this action. The benoclors and diesel oil apparently act by dissolving the chloroplasts (or the chlorophyll in them) thus robbing the plants of their mechanism for obtaining energy from sunlight. The oil probably coats catalytic surfaces, thus decreasing respiratory activity. Many of the herbicides are phenol derivatives and may act like phenol which inhibits mitosis and increases the respiratory quotient of plants, i.e., prevents growth and, by decreasing the oxygen intake, decreases the energy available to sustain life. 2,4-D (and apparently also ammonium sulphamate) burn up the starch and sugar reserves. They stimulate plant growth in very low concentrations but are lethal in higher concentrations. Nigrosine dye, water bloom, and filamentous algae

prevent light from reaching the larger submerged aquatics and so prevent photosynthesis.

REFERENCES

Breusch (1944)
Brooks (1946)
Brown (1946)
Eicher (1948)
Gauthier (1944)
Gavaudan and Poussel (1944)
Goudey (1946)
Mitchell and Brown (1945)
Mitchell and Brown (1946)
Oberle, Pearce, Chapman and Avens (1944)
Smith (1935)
Walter and Nelson (1945)

Chemical Controls

1. *Copper Sulphate:* $CuSO_4, 5H_2O$

Copper sulphate is particularly useful for controlling *Chara*, a submerged aquatic which is not seriously affected by most other herbicides. It has also been used to control floating algal scums (as *Cladophora*) and Pondweeds (*Potamogeton*); but sodium arsenite is a better herbicide for these, for Smith (1936) found that Potamogetons were not affected by 3 p.p.m. of copper sulphate in Lake Jesse, Nova Scotia.

Copper sulphate may be applied in several ways: (1) it may be dissolved and sprayed over the water surface, (2) the crystals may be put in a burlap bag which is towed behind a boat until the crystals have all dissolved, (3) the bag of crystals may be suspended in a current of water, above the region where it is to take effect (as the inlet to a pond). In lakes it should be applied on a windy day (when there is a good circulation of water).

Various authors suggest concentrations from 0.12 to 2.0 p.p.m. (parts per million by weight) for control of *Chara* and other algae. The concentration to be used depends upon the temperature, alkalinity and organic content of the water. Organic and alkaline waters remove the copper by precipitation. Moore and Kellerman (1904) suggested that the effective concentration at 15°C should be increased 2.5% per drop of 1°C; an increase in concentration of 0.5% per 10 p.p.m. of HCO_3; and an increase of 2% per 10 p.p.m. of organic matter in the water.

The algae and other *submerged* aquatics are killed (emergent forms are little affected). When they die, bacteria in the water increase and the weeds decay. Fish and other aquatic animals are apt to be killed at this time *by lack of oxygen.* This danger may (in the case of ponds with a controllable flow of water) be avoided by adding plenty of fresh water when plant decay begins. The concentration of copper sulphate necessary to kill fish varies a great deal with the alkalinity of the water and also with the species of fish: bullheads, eels and killifish are particularly resistant. Kellerman (1912) found that 1 p.p.m. killed fish (bullheads, suckers, trout) while in the hard waters of Lake Mendota in Wisconsin, 150 p.p.m. were needed to kill largemouth bass. Smith (1924) tabulated the effects on various fish and algae. Some authors recommend that cattle be excluded from treated water for several days while others say that the drinking of treated water is not harmful in concentrations used. The chief danger appears to be the production of a toxic water bloom following death of the poisoned aquatic plants (which then act as an organic fertilizer).

REFERENCES:

Brown (1940)
Caird (1904)
Caird (1905)
Carpenter (1927)
Carroll (1904)
Catt (1934)
Ellms (1905)
Ellms (1928)
Harkness (1933)
Kellerman (1912)
Marsh & Robinson (1908)
Moore & Kellerman (1904)
Moore & Kellerman (1905)
O'Donnell (1943)
Smith, G. M. (1924)
Smith, H. E. (1905)
Smith, M. W. (1935)
Smith, M. W. (1936)
Surber (1943)
Titcomb (1914)
Whipple (1927)
Wickliff (1931)

2. *Sodium Arsenite:* $-NaAsO_2$ (mostly)
$-Na_3AsO_3$ (some)

Surber (1948) recommends sodium arsenite as the cheapest and best herbicide for the control of pond scum algae and such submerged aquatics as *Potamogeton*, *Anacharis* and *Naias* in small ponds. However, it does not control *Chara*, *Scirpus* (or other emergent forms), or *Nymphaea.*

This herbicide may be applied by spraying it over the water surface as recommended for copper sulphate.

Surber (1948) recommends a concentration of 4 p.p.m. of the commercial form which contains 32% As_2O_3, i.e., a concentration of 1.3 p.p.m. of As_2O_3 is suggested. At this concentration no significant fish mortality was noted. A concentration of 10 p.p.m. killed only 13% of the largemouth bass in one pond over a ten day period, while in another experiment bluegills and crappies survived 12 p.p.m. for 6 days.

As in the case of copper sulphate, however, there is the danger of fish mortality due to oxygen depletion while the killed vegetation is decaying. This should be guarded against by adding plenty of fresh water to the pond during this period (usually beginning about 2 days after application of the herbicide). It is also recommended that cattle be excluded for several days after treatment. Drinking water *must not* contain more than 0.05 p.p.m. of arsenic.

REFERENCES:

Brown (1940)
Surber (1929)
Surber and Meehean (1931)
Surber (1932)
Surber (1943)
Surber (1947)
Surber (1948)

3. *De-K-Pruf-21:*

The chemical composition of this product is not known the writer, except that it contains copper. No information is available except from The Unexcelled Chemical Corporation, 11 Park Place, New York, 7, New York, who produce this product.

They recommend it for the control of algae on surfaces such as the cement or wooden sides of fish breeding tanks.

It is applied by draining the tanks for 48 hours, then spraying or brushing on the chemical. For spraying it should be thinned with No. 10 mineral spirits.

Rates of application from 150 to 250 sq. ft. per gallon for first coats and up to 400 sq. ft. per gal. for subsequent treatments are recommended.

No ill effects on fish were noted, the copper concentration in the water being less than 1 p.p.m.

The chemical apparently contains enough copper to inhibit the growth of algae and by making a smoother surface to the tanks allows them to be cleaned more easily when eventually algae do begin to collect again.

REFERENCES:—Anonymous (1947)

4. *Sodium Chlorate:* $NaC10_3$

Sodium Chlorate may be used to control both submerged and emergent aquatics, but due to its fire hazard characteristics, it is *not* recommended for either purpose.

A concentration of 2 to 4% by weight in water solution may be used in spraying emergent vegetation. A wetting agent such as whale oil soap or Vatsol should be used with it. No information is available on concentrations needed for control of submerged aquatics, nor on the effects of the chemical on fish in the treated water or on cattle drinking it.

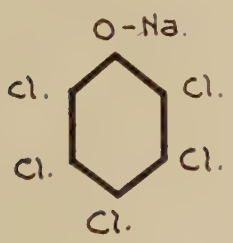
REFERENCES:—Crafts (1945); Surber (1948).

5. *Chloramine:* NH_2C1.

Chloramine may be used instead of copper sulphate for the control of algae. It is prepared by dissolving 1 part by weight of ammonium sulphate in a little water adding 3 parts by weight of chloride of lime and diluting in water sufficient for spraying. It should be applied by spraying evenly over the water surface. The concentration recommended (Harkness, 1933) is 4 p.p.m. (3 lbs. chloride of lime plus 1 lb. ammonium sulphate per 100,000 gals. water). In this concentration, it is not likely to be directly harmful to cattle, fish or to swimmers, but the same precautions should be used as recommended for copper sulphate.

REFERENCES:—Harkness (1933)

6. *Santobrite:*



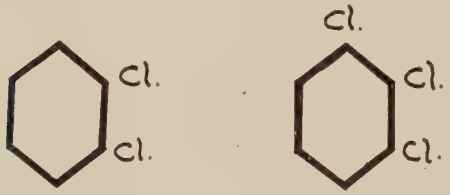
This chemical has been found effective in controlling water hyacinth, *Crassipes eichornia*, and is recommended for controlling algae in industrial cooling systems by Monsanto Chemical Corporation, St. Louis, Missouri. (Copper sulphate at 45 p.p.m.; and Benaclor 3 at 45 gal. per acre were not effective in controlling water hyacinth).

Growth of water hyacinth was retarded by a concentration of 5 p.p.m., while 80 p.p.m. were used to completely eliminate it. As an algicide, a maxi-

mum concentration of 13 p.p.m. has been recommended. At 80 p.p.m. it does not produce skin irritation. It is implied that 5 p.p.m. is not harmful to aquatic animals while 80 p.p.m. is harmful, but no definite data are given.

REFERENCES:—Hildebrand (1946); Hirsch (1942).

7. *Benoclor:*



(Positions of C1 on rings uncertain—J.M.S.)

The Cloroben Corporation, Jersey City 2, N.J., puts out a variety of herbicides: Benoclor 3, Benoclor 3C, etc., apparently dichlorbenzol and trichlorbenzol with added emulsifiers. These are recommended for control of submerged and emergent aquatics in situations where fish and other aquatic life are relatively unimportant (as in some irrigation and drainage ditches). *Chara* and *Anacharis* are very susceptible. Pondweeds are not so vulnerable. Emergent plants (*Scirpus*, *Typha*, etc.) must be cut below the water line before treatment (on the same day as treated).

The benoclors are heavy liquids, usually applied by spraying them *underwater.* They sink to the bottom and appear to remain effective for several years (Crafts, 1945).

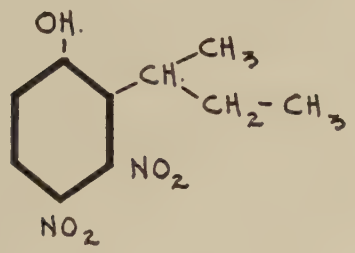
Very clear directions for use are issued in a pamphlet, "Aquatic Weed Control Manual" issued by Benoclor Corporation. Concentrations of 20-30 gals. per acre used to control pondweeds (*Potamogeton Robbinsii*) and water shield (*Brasenia*) in portions of a 195 acre lake in New Jersey. These were given two treatments (35 acres treated with 750 gals. in June-July; and 25 acres including some of the former area with 700 gals. in September). The total cost for this treatment was over $3,000. Costs for ditch treatments were about $50 per mile. Before concentrations strong enough to kill plants are reached, Benoclor kills aquatic life including fish, frogs, crayfish, mosquito larvae, and bacteria, producing a "slow, lingering death". Claims are made that fish mortality in lakes may be minimized by applying the solution in narrow strips. Due to unpleasant taste, livestock and birds will not drink the water so are apparently not endangered. When the water is used for irrigation, treatment should not be made until crops have passed the seedling stage as germinating and seedling plants are affected by it.

REFERENCES:—Boyer (1947); Crafts (1945); McGeorge (1946); Surber (1948).

8. *Dow Contact Herbicide:*

This is used as a contact herbicide for spraying ditchbank emergents such as cattails (*Typha*) and bulrushes (*Scirpus*).

It is used in a concentration of 4 gals. per 100 gals. water and is sprayed on the emergents.



(Position on ring uncertain—J.M.S.)

=dinitro ortho secondary butyl phenol in a self-emulsifying oil.

REFERENCES:—Crafts (1945).

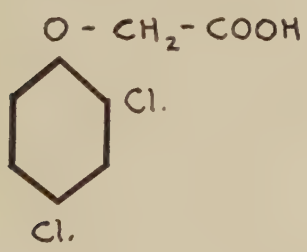
9. *Ammate = Ammonium sulphamate:* NH_4,SO_2,NH_2.

This is useful in the control of emergent aquatics. It may be used in treating submerged vegetation over small areas but it is considered too expensive for treating large areas.

A 5% solution used with a wetting agent such as whale oil soap or Vatsol is recommended for spraying emergent vegetation. Concentrations necessary to kill submerged vegetation are not given.

REFERENCES:—Crafts (1945); Surber (1948).

10. 2,4-*dichlorophenoxyacetic Acid:*



This is recommended for control of emergent vegetation, such as cattails (*Typha*), spikerush (*Eleocharis*), bulrushes (*Scirpus*), burreed (*Sparganium*), and willow (*Salix*). It has been used experimentally to control submerged aquatics such *Anacharis*, *Potamogeton*, and *Naias*.

In the control of emergent vegetation, it should be applied in a spray with tributylphosphate as cosolvent and kerosene as carrier. For example, to make a 5% 2,4-D spray use 2 lbs. of 2,4-D, 2 quarts of tributylphosphate, and kerosene to make 5 gals. The 2,4-D should first be dissolved in the cosolvent, then diluted with the kerosene and thoroughly mixed. This oil spray has two advantages over water solutions of similar concentration: (1) the tributylphosphate has herbicidal properties and rapidly penetrates plant

tissues, (2) it imparts a glistening appearance so that it may be readily seen which parts have been sprayed.

This solution has the disadvantage that the tributylphosphate is very poisonous to fish, so should be used only on emergent vegetation. This 5% solution sprayed at a rate of 20 gals. per acre has been found very effective in controlling cattails and other emergents. Linton (1947) considered the action on willows and other shrubs was largely due to the oil carrier and found that the kill was not permanent. For submerged aquatics, triethanolamine may be used as cosolvent and water as a carrier: 1 lb. of 2,4-D to 1 qt. of cosolvent. Concentrations of 5 p.p.m. were effective in aquarium experiments in killing *Anacharis*, *Potamogeton crispus*, and *P. nodosus;* but in outdoor large scale tests, 10 p.p.m. were required to kill *P. foliosus*, *P. filiformis* and *Naias flexilis*. The cost per acre for control of submerged aquatics is generally over $100. In a concentration of 100 p.p.m., 4 of 20 fish died—possible due to oxygen lack in decaying vegetation. Treated water is not harmful to cattle and sheep, but the possibility of a toxic water bloom developing in the decaying killed weeds should not be overlooked.

REFERENCES:

Hildebrand (1946)
King and Penfound (1946)
Linton (1947)
Mitchell et al (1946)
Offord (1946)
Surber (1943)
Surber (1947)
Surber (1948)

11. *Other Growth Regulators:*

A number of substances related to 2,4-D have been used at least experimentally for aquatic weed control. These include:

(A) 2,4,5—trichlorophenoxyacetic acid (2,4,5-T)
(B) SLI-23 (a modified sodium salt of 2,4-D)
(C) 2-methyl-chlorophenoxyacetic acid
(D) Indole-acetic acid
(E) Naphthalene-acetic acid
(F) Indole-butyric acid
(G) Indole-propionic acid
(H) Phenyl-acetic acid

The actions of (A and B) on submerged aquatics were very similar to 2,4-D in similar concentrations. (C) is considerably more toxic to fish (1 p.p.m. killed 2 fish and 100 p.p.m. killed all fish in 24 hours).

(D to H) stimulated growth of aquatic green algae in low concentrations, such as:

10 p.p.m. of D- 4 p.p.m. of E 6 p.p.m. of F,G 35 p.p.m. of H	a sugar solution added with D had an inhibiting effect.

They killed algae in higher concentrations, such as:

30 p.p.m. of D to G 100 p.p.m. of H

REFERENCES:—Brannon and Bartsch (1939); Surber (1948).

12. *Diesel Oil:*

This is useful in the control of ditchbank emergents, where it is sprayed full strength on the bulrushes, etc.

REFERENCES:—Crafts (1945)

13. *Nigrosine (a black aniline dye):*

This is useful in inhibiting the growth of submerged aquatic plants.

In one experiment, it was applied at rates of 10 or more lbs. per acre of water. This concentration inhibited the growth of *Myriophyllum* not only during the year of application but during the following year. There was a temporary increase in plankton, possibly due to the fertilizing effect following the decay of *Myriophyllum*. The bottom temperatures of the treated ponds and lakes were also lowered appreciably.

The dye cost $15 per lb. or $36 per 100 lbs.

REFERENCES:—Eicher (1948)

14. *Fertilizers:*

These are recommended for destruction of submerged aquatics in *large* ponds. They operate by producing an algal "bloom" or dense growth of filamentous algae which shade out the larger submerged aquatics.

The most successful fertilizer in one series of experiments was 10-5-5, made up of ammonium sulphate $(NH_4)_2SO_4$; superphosphate $(Ca(H_2PO4)_2)$; and potassium muriate (KC1) in such proportions as to give 10 parts (by wt. of) N, 5 parts P, 5 parts K. The fertilizers should be applied at a rate of about 100 lbs. per acre, or 1 p.p.m. The cost was about 5c. per lb.

If *too much* fertilizer (e.g. 10 p.p.m.) is added, pond scum algae such as *Cladophora* are apt to develop. This produces unfishable water. Oxygen depletion is apt to occur, killing fish. Dead algae have been shown in some cases to produce toxic substances causing cattle poisoning and even fish mortality. Even the production of a normal water bloom is apt to produce poor fishing.

Combinations of organic fertilizers (such as cottonseed meal, soybean meal, sheep manure, etc.) with superphosphates are not recommended as they are apt to encourage pond scum, *Chara* and other algae so that even if fish production is increased fishing is rendered impracticable.

REFERENCES:—

Fitch et al (1934)
Smith and Swingle (1941)
Surber (1943)
Surber (1948)

Biological Controls

1. *Water Bloom Algae:*

Submerged aquatics may be killed by stimulating the growth of water bloom algae. For details, see Chemical Controls—Fertilizers.

2. *Carp:*

Carp may be introduced to control submerged aquatics but this is *not* recommended until a careful study has been made of the desirability of carp in the waterway system into which introduction is proposed.

Carp control submerged vegetation both by rooting it out and by increasing the turbidity of the water so that photosynthesis is impaired or prevented.

REFERENCES:—Black (1946); Wickliff (1931).

Mechanical Controls

1. *Hand weeding:*

This method is recommended for control of cattails when only a few are present. It is too expensive, and not very effective, in established stands, since the rhizomes become interlaced and are very difficult to completely remove: unless removal is complete the stand rapidly becomes re-established.

REFERENCES:—Crafts (1945); Surber (1948).

2. *Hand Cutting and Raking:*

This method is used for control of aquatics along lake margins, and in ditches and canals in which the weeds seriously impede the flow of water. Since many of the submerged aquatics grow well from cuttings, this method may be no more than a temporary control and may even aid in the spread of the species. As it involves a lot of labour, it is a very expensive method. Wickliff (1931), however, recommended persistent cutting and raking to control pond lilies, pondweeds, rushes, cattails and sedges. He claimed that after the third cutting such plants will usually die.

REFERENCES:—Crafts (1945); Wickliff (1931).

3. *Fire Hose and High Pressure Nozzle:*

By first draining a pond, this method may be used to root out aquatics which form a mat along its bottom. *Eleocharis* has been controlled in some ponds by this method.

REFERENCES:—Surber (1948).

4. *Plowing:*

Eleocharis may be plowed under after its roots have formed a mat but not until the pond is first drained and allowed to dry sufficiently for plowing.

REFERENCES:—Surber (1948).

5. *Draining:*

Burreed (*Sparganium*) and some other aquatics may be killed by draining the pond and allowing it to dry out thoroughly.

REFERENCES:—Crafts (1945); Surber (1948).

6. *Mechanical Weeder:*

Various mechanical weeders are used to keep navigation channels open. Like hand cutting and raking, their effect is only temporarily beneficial, the

ultimate result aiding in the spread of the very weeds whose control is being attempted.

REFERENCES:—Brown (1940); Crafts (1945).

7. *Dredging:*

This method effectively removes all aquatics both submerged and emergent from drainage and irrigation ditches but costs from $100 to $1,000 per mile of ditch. The control is not permanent as the weeds are piled up along the ditch banks and eventually grow again.

REFERENCES:—Crafts (1945).

8. *Chaining:*

In this method, a very heavy chain is dragged along the bottom of a ditch by tractors or teams, one on each bank. At intervals, the chain is cleared of the accumulated aquatics with rakes and piled on the ditch banks. The immediate cost of this method is much less than the cost of dredging but the effect is more temporary.

REFERENCES:—Crafts (1945).

9. *Burning:*

Various "flame-throwers" or "sizz-weeders" have been used very effectively to control emergent aquatics along ditchbanks.

REFERENCES:—Crafts (1945).

SUMMARY

Several methods are generally available to control particular aquatics. To control emergent aquatics such as cattails, bulrushes and spike rushes, 2,4-D or ammate probably give the most permanent control: dredging and the use of a flame thrower are effective as temporary controls. To control undesired algae, copper sulphate appears to be the best chemical at present: chloramine may be equally useful but has not been so thoroughly tested: for algae coating concrete or wooden walls of fish tanks or reservoirs, De-K-Pruf-21 is suggested. For pondweeds the most effective control appears to be sodium arsenite but this chemical must be used with caution where it is likely that the water will be later used for drinking purposes by mammals (including man): the benoclors are effective controls where fish and other aquatic animals are unimportant: nigrosine dye may be used to shade out the pondweeds where the black colour imparted to the water is not a consideration; in some waters pondweeds have been controlled by adding enough fertilizer to the water to produce a water bloom which shades out the pondweeds: this method may have merit where dense growths of algae are considered preferable to growths of pondweeds. Water-lilies are particularly resistant to chemical methods of control: persistent cutting is the only method of control which appears to give satisfactory results as yet.

The writer wishes to thank the Ontario Research Commission, under whose auspices this bibliographic research was carried on; Eugene W. Surber and G. M. Linton for permission to quote from their letters; Miss J. M. Graham, F. E. J. Fry, R. R. Langford, G. H. W. Lucas, and T. F. West for critical reading of parts of the manuscript and technical assistance.

REFERENCES

Anonymous (Enexcelled Chemical Corporation).
1947. *A report on algae control in fish hatchery tanks.* Unexcelled Chemical Corporation, 11 Park Place, New York 7, N.Y.

Anonymous (Wisconsin: Committee on Water Pollution).
1939. *Report on the chemical treatment of lakes and streams with special reference to the origin and control of swimmers itch.* State of Wisconsin: Committee on Water Pollution, 20 pp.

Black, John D.
1946. *Nature's own weed killer—the German carp.* Wis. Cons. Bull., 11 : 3-7.

Boyer, Burleigh B.
1947. *Aquatic weed control manual.* The Cloroben Corporation. 15 Exchange Place, Jersey City 2, N.J.

Brannon, Melvin A. and Alfred F. Bartsch.
1939. *Influence of growth substances on growth and cell division in green algae.* Am. Journ. Bot., 5 : 271-279.

Breusch, F. L.
1944. *The specific inhibition of post-mortem tissue respiration in tissue pulp.* Rev. Faculte Sci., Univ. Istanbul, 9A : (1); 1-4. (In German).

Brookes, Vincent J. and Hubert N. Alyea.
1946. *Poisons, their properties, chemical indentifications, symptoms, and emergency treatments.* New York, D. Van Nostrand Co., 219 pp.

Brown, C. J. D.
1940. *Water weeds—their value and control.* Mich. Cons., 9 : (10); 6, 7, 11.

Brown, James W.
1946. *Effect of 2,4-dichlorophenoxyacetic acid on the water relations, the accumulation and distribution of solid matter, and the respiration of bean plants.* Bot. Gazette, 107 : 332-343.

Caird, J. M.
1904. *The copper sulphate treatment for algae at Elmira, N.Y.* Engineering News, 52 : 34.

Caird, J. M.
1905. *The copper sulphate treatment for algae at Middletown, N.Y.* Engineering News, 53 : 33-34.

Carpenter, K. E.
1927. *The lethal action of soluble metallic salts on fishes.* Brit. Journ. Exp. Biol., 4 : 378-390.

Carroll, Eugene.
1904. *Treatment of reservoir of the Butte Water Co. with copper sulphate.* Engineering News, 52 : 141-143.

Catt, James.
1934. *Copper sulphate in the elimination of coarse fish.* Trans. Am. Fisheries Soc., 64 : 276-280.

Crafts, A. S.
1945. *Control of aquatic weeds.* Mimeogr. Univ. Cal. Div. Bot. Coll. Agr.

Eicher, George.
1947. *Aniline dye in aquatic weed control.* Progressive Fish-culturist : 39-42. (Reprint from Journ. Wildlife Man., 11 : 193-197). (Jan., 1948).

Ellms, J. W.
1905. *Behaviour and uses of copper sulphate in the purification of hard and turbid waters.* Journ. New Eng. Water Works Assoc., 19 : 496-503.

Ellms, J. W.
1928. *Water purification.* 2nd ed., pp. xii, 594. McGraw-Hill Book Co., New York.

Fitch, C. P., Lucille M. Bishop, W. L. Boyd, R. A. Gortner, C. F. Rogers, and J. E. Tilden.
1934. *"Water bloom" as a cause of poisoning in domestic animals.* Cornell Veterinarian, 24 : (1); 31-40.

Gauthier, Pierre Paul.
1944. *Toxic Gases.* J. Hotel-Dieu Montreal, 13 : 322-334.

Gavaudan, *P.* and H. Poussel.
1944. *Narcotic theory of inhibition of mitosis; value of the lipoid solubility hypothesis in the benzene series.* Compt. Rend. Soc. Biol., 138 : 246-247.

Goudey, R. F. (Dept. Water & Power, Los Angeles, Cal.).
1946. *Chemical weed control.* J. Amer. Water Works Assoc., 38 : 186-202.

HARKNESS, W. J. K.
1933. *Report on the control of algae in the ponds of Mr. J. Moore Greenwood at Clarkson, Ontario.* Manuscript.

HILDENRAND, E. M.
1946. *War on weeds.* Science, 103 : 456-468, 492.

HILDEBRAND, E. M.
1946. *Herbicidal action of 2,4-dichlorophenoxyacetic acid on the water hyacinth.* Science, 103 : 477-479.

HIRSCH, A. A.
1942. *Toxic effects of sodium pentachlorphenate and other chemicals on water hyacinth.* Bot. Gazette, 103 : 620-621.

KELLERMAN K. F.
1912. *The rational use of disinfectants and algicides in municipal water supplies.* Eighth Int. Cong. Appl. Chem., 26 : 241-245.

KING, JOSEPH E. and WILLIAM T. PENFOUND.
1946. *Effects of two of the new formagenic herbicides on bream and largemouth bass.* Ecology, 27 : 372-374.

LINTON, G. M.
1947. *Report on experiments with 2,4-D.* Letter to R. N. Johnston.

MARSH, M. C. and R. K. ROBINSON.
1908. *The treatment of fish-cultural waters for the removal of algae.* Bull. U. S. Bur. Fish., 28 : 873-890.

MCGEORGE, W. T.
1946. *Experiments with benoclor.* Mimeographed reprint of report to Salt River Valley Water Users' Association. (Univ. Ariz. Coll. Agr. & Agr. Exp. Sta.).

MITCHELL, JOHN W. and JAMES W. BROWN.
1945. *Effect of 2,4-dichlorophenoxyacetic acid on the readily available carbohydrate constituents in annual morning-glory.* Bot. Gazette, 107 : 120-129.

MITCHELL, JOHN W. and JAMES W. BROWN.
1946. *Movement of 2,4-dichlorophenoxyacetic acid stimulus and its relation to the translocation of organic food materials in plants.* Bot. Gazette, 107 : 393-407.

MITCHELL, J. W.; R. E. HODGSON, and C. F. GAETJENS.
1946. *Tolerance of farm animals to food containing 2,4-dichlorophenoxyacetic acid.* Journ. Animal Sci., 5 : 226-232.

MOORE, G. T. and K. F. KELLERMAN.
1904. *A method of destroying or preventing the growth of algae and certain pathogenic bacteria in water supplies.* U.S. Dept. Agric., Bur. Plant Ind., Bull 64 : 1-44.

MOORE, G. T. and K. F. KELLERMAN.
1905. *Copper as an algicide and disinfectant in water supplies.* U.S. Dept. Agric., Bur. Plant Ind., Bull. 76 : 1-55.

OBERLE, G. D., G. W. PEARCE, P. J. CHAPMAN, and A. W. AVENS.
1944. *Some physiological responses of deciduous fruit trees to petroleum oil sprays.* Proc. Am. Soc. Hort. Sci., 45 : 119-130.

OFFORD, H. R.
1946. *Rapid estimation of the phytocidal action of chemicals.* Science, 103 : 474-476.

SMITH, E. V. and H. S. WINGLE.
1941. *The use of fertilizer for controlling the pondweed.* Morong. Trans. Sixth N. Am. Wildlife Conf.: 245-251.

SMITH, G. M.
1924. *Ecology of the plankton algae in the Palisades Interstate Park, including the relation of control methods to fish culture.* Roosevelt Wild Life Bull., 2 : 93-195.

SMITH, H. E.
1901. *Poisoning by copper, in:* A Reference Handbook of the Medical Sciences, edited by A. H. Buck, 3 : 279-280. Wm. Wood and Co., New York.

SMITH, M. W.
1935. *The use of copper sulphate for eradicating the predatory fish population of a lake.* Trans. Am. Fisheries Soc., 65 : 101-114.

SMITH, M. W.
1936. *Copper sulphate and the destruction of undesirable fish in lakes.* Biol. Bd. Can., Progress Reports Atl. Biol. Sta. No. 17 : 8-9.

SURBER, EUGENE, W.
1928. *The use of sodium arsenite in controlling submerged vegetation in fish ponds.* U.S. Bur. Fisheries; Sp. Paper : 1-2.

SURBER, E. W. and O. L. MEEHEAN.
1931. *Lethal concentrations of arsenic for certain aquatic organisms.* Trans. Am. Fish. Soc., 61 : 225-239.

SURBER, EUGENE W.
1932. *Controlling vegetation in fish ponds with sodium arsenite.* U.S. Bur. of Fish., Inv. Report. 11 : 39 pp.

SURBER, EUGENE W.
1943. *Effects of various fertilizers on plant growths and their probable influence on the production of smallmouth black bass in hard-water ponds.* Progressive Fish-culturist.

SURBER, EUGENE W.
1943. *Weed control in hard-water ponds with copper sulphate and sodium arsenite.* Trans. 8th N. A. Wildlife Conf. 1943.

SURBER, EUGENE W.
1947. *Aquatic plant control with 2,4-D.* U. S. Dept. Int. Fish & Wildlife Serv. Fishery Leaflet 217 : 1-6.

SURBER, EUGENE W., C. E. MINARIK and W. B. ENNIS.
1947. *The control of aquatic plants with phenoxyacetic compounds.* Progressive Fish-culturist: 143-150.

SURBER, EUGENE W.
1948. *Aquatic herbicides.* Letter to J. Murray Speirs.

TITCOMB, J. W.
1914. *The use of copper sulphate for the destruction of obnoxious fishes in ponds and lakes.* Trans. Am. Fisheries Soc., 44 : 20-26.

WALTER, ELSIE M. and J. M. NELSON.
1945. *Further studies on tyrosinase in aerobic plant respiration.* Arch. Biochem., 6 : 131-138.

WHIPPLE, GEORGE CHANDLER. (Revised by G. M. FAIR and M. C. WHIPPLE).
1927. *The microscopy of drinking water.* John Wiley & Sons, Inc., N.Y.: 586 pp.

WICKLIFF, E. L.
1931. *Methods of controlling undesirable aquatic plants in ponds, lakes and other quiet waters.* Ohio Dept. Agr. Div. Cons. Paper No. 20 : 1-2.

Turbines and Descending Salmon and Trout Smolts (and Eels) : IV

Review by

A. L. Pritchard

(Director of Fish Culture Development, Department of Fisheries)

Turbines and Descending Salmon and Trout Smolts (and Eels) : IV., by C. V. Otterstrom. Report of the Danish Biological Station, XLVII, 1942, Copenhagen 1945.—11 pages, 10 text figures.

This paper, recently come to hand, reports on a number of experiments on turbines of various types and sizes in order to discover how great a danger such machines present to fish.

In the first series of tests investigations were made on two Francis turbines of the Finshyttan system, those of the stamp mill of Ribe and the middle mill of Ribe. These have runners with a diameter of 104-173 cm. (40.9—68.1 in.) with 13 bucket vanes. The guide vanes number 20, are 63 cm. (24.8 in.) in height and adjustable with a maximum aperture of 15 cm (5.9 in.). The rotation speed is about 80 revolutions per minute. Fish of various types including roach, rudd, perch, pike, rainbow trout and eel were inserted into the machine through a wooden trough and collected in a bag at the spillway gates. Since a comparatively small number were hurt, the conclusion was reached that turbines such as these "must be considered in the main harmless to the descending trout and salmon smolts; but probably some of the silver eels would be spoilt by passage through the turbines, and hence it is desirable that the eels are caught before getting so far."

The second series of tests was carried out on the turbine at the Holstebro power station. This is the Kaplan type, 870 h.p., having a runner diameter of 1500 mm. (49.2 ft.), 4 bucket vanes and a constant speed of 214 revolutions per minute. The vanes are adjustable being nearly in a vertical position with the greatest space between them when the turbine is running at full charge (about 500 kw.) but being turned more horizontally with a comparatively small space at low charge (e.g. 130 kw.). A charge of 300 kw. is most frequently used. Fish including roach, dace, pike, rainbow trout and eel were fed into the turbine through a rubber hose with the operation at various charges. This type of turbine is far from harmless with damage at low charge where it usually operates, obviously much higher than at full charge. The majority of salmon and trout smolts will pass through fairly well but so many eels were killed that it was recommended that they be taken before reaching the turbines.

In connection with the above paper, it is interesting to quote from a presentation by Mr. Harlan B. Holmes concerning similar work on the Columbia river, U.S.A., entitled—The Passage of Fish at Bonneville Dam (Dams and the Problem of Migratory Fishes—Special Symposium Issue. Stanford Ichthyological Bulletin, Vol. 1, No. 6, May 3, 1940, pp. 183 and 184).

"A series of laboratory and field tests revealed the fact that, from the standpoint of the passage of fish, hydraulic turbines differ all the way from

literal sausage grinders to a very satisfactory route for the passage of fish. The Bonneville turbines, due to their great size, low pressure, slow speed and type of design, fortunately fall at the latter end of this range of variation, leaving little to worry about. Consideration of screening therefore was discontinued.

From the standpoint of passage of fish, one of the Bonneville turbines can be visualized by considering a vertical cylinder in which a propeller similar to a ship's propeller is mounted in such a way that water flowing downward through the cylinder, will turn the propeller. . . . The runner is 23 feet in diameter, and rotates at a constant speed of 75 revolutions per minute.

After dispensing with the problem of the passage of fish through the turbines, there remained the question of possible injury to the fish that would pass under the spillway gates. Laboratory experiments had demonstrated that the pressure conditions would not be injurious, but there remained the general turbulence below the spillway. It was not possible to make such analysis of this condition. We still should be worried about the situation, were it not for the general observation that seaward migrants regularly pass through similar turbulent conditions at natural and artificial obstructions, such as at Celilo Falls on the Columbia and at Oregon City Falls on the Willamette."

OTTAWA
EDMOND CLOUTIER, C.M.G., B.A., L.Ph.,
PRINTER TO THE KING'S MOST EXCELLENT MAJESTY
CONTROLLER OF STATIONERY
1948